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(54) **Stone cutting tool having diamond segments with variable height, width and length**

(57) Tool (1) for cutting marble, granite or stone in general comprising a metal core (10), for example a disk or a blade, and a diamond segments (12,14,16) applied by welding to the core, arranged in repeated sequences of three different segments. The segments contained in each sequence have progressively decreasing heights and increasing cutting widths in the cutting direction of the tool. These segments have different lengths to maintain constant their volume and therefore the amount of abrasive material present in each segment. At least one of the segments comprised in a sequence has a central frontal drainage (60,62) made of a longitudinal groove.

Abrasive segment (30) comprises at least two different portions (32,34,36), arranged in sequence according to a cutting direction of the tool, each portion having, relative to the portion preceding it in the sequence, respectively lower height and greater cutting width.

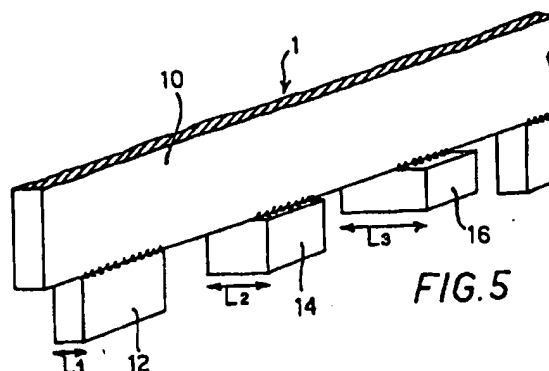


FIG. 5

Description

[0001] The present invention refers to a tool provided with segments or sectors or diamond plaques, used for cutting marble, granite, stone in general, conglomerate, cements and similar materials, and to a relative cutting method.

[0002] In particular the invention refers to a set of diamond segments, containing natural or artificial diamond particles or other hard materials, applied to the external circumference of a disk or on a longitudinal side of a blade.

[0003] Disks and Blades are generally used for different applications, because of their different uses. The comparison between diamond disks and blades highlights the substantially different use made of diamond plaques applied respectively to the external circumference of the disks or to a longitudinal side of the blades.

[0004] The differences are substantially in the cutting directionality, cutting speed and speed constancy.

[0005] The disk in fact rotates always in the same direction while the blades work with an alternating movement varying cyclically the cutting direction. This continuous changing in the cutting direction makes difficult the permanence of the single diamond in the binder in which it is immersed. The bi-directional stress tends to undermine it from its seat, often before its useful life ends, shortening therefore the useful life of the tool.

[0006] The disk can rotate at a speed believed optimal for cutting the material. Such speed is suggested to be about 20 m/s for cutting granites rich in quartz and hard stones while rises to 40 m/s and over for cutting calcareous and soft stones. In a gang saw blade the reciprocating movement and the relevant masses involved limit the possible speed of the tool on the material at values that are less than a tenth than that possible in a disk.

[0007] The speed of the disk is constant while that of the blade is like a sinusoid that starts from zero, accelerates up to the maximal speed at half travel for returning to zero, for repeating in next movement in the opposite direction.

[0008] Notwithstanding the fact that disks and blades are used differently there are not substantial differences in the diamond segments used.

[0009] The more evident differences found in diamond segments are, on the contrary, in relation with the hardness of the material to be cut, for marble and soft stones are used in fact synthetic diamond and binders different from that used for granites rich of quartz and hard stones in general.

[0010] Although the studies and experiments about binders and artificial and natural diamonds continue respectively on the metallic alloys used and in the processes for laying the diamonds improving adhesion, at the actual state of the art the tools for marble are made of bronze based alloys while the tools for granite are made of alloys in which prevails cobalt. Since for cobalt

are necessary higher sintering temperatures the synthetic diamonds used must have a better resistance to high temperatures.

[0011] Moreover, using present technologies, while diamond disks are used in single or multi-disk machines for cutting either siliceous hard stones or calcareous soft stones, in mono or multi blade frame saws the diamond segment blades are used only for cutting marbles, travertine, calcareous onyx, soft stones, sandstone and similar.

[0012] Cutting granite or hard stones by means of gang saws is normally performed using metallic grit as abrasive which, carried by the water and mixed with additives, cuts the material because of the entrainment made by the steel blades having a substantially rectilinear reciprocating movement in contact with the material to be cut.

[0013] The attempts made until now for cutting granite and hard stones using blades containing artificial or natural diamond particles hold by various binders, copper, copper and cobalt and other metals, didn't give valuable results as tool life and therefore cutting costs for square meter cut.

[0014] Special-purpose gang saws have been built, normally having vertical blades relative to the block to be cut, using various tricks, for example making the blades travel ellipsoidal movements on parallel strokes in which the diamond segments are in contact with the block only during the active cycle. However has never been built a diamond blades gang saw which is technically and economically efficient and that can substitute the present frame machines for granite, using metallic grit, with analogous cutting costs.

[0015] A gang saw equipped with diamond segment blades suitable for cutting hard stones could have obvious environmental advantages relative to a metallic grit frame machine that produces pollutant residual that is expensive and problematical to dispose.

[0016] Lower durability and greater costs for cutting granite and hard stones using diamond disks, compared with wear and costs for cutting marble and soft stones, is certainly correlated with the hardness of materials. Granites are at level seven of the Mohs hardness scale, a hardness which is much near to that of diamond, which is ten, then marbles that are at level three. However, together with the hardness of the material to be cut, is to be considered also the problem of fast wear of tools and the insufficient and too difficult drainage of the abraded material from the cutting area.

[0017] During disk cutting the material abraded by each segment remains imprisoned in the space that separates that segment from the following segment while all the abraded material which is generated interferes with the sides of the segment. The more is hard the material to be cut the more is sharp the counter-abrasive effect on the diamond tool. Moreover the open lateral spaces over the diamond segment, due to the difference of thickness between the radial tools and the

disk core, are progressively reduced with the wearing out of the diamond segments, progressively making worse the situation and accelerating the process. For this reason the present trend is for cutting granite by means of a plurality of low dept passes reducing therefore to the minimum the number of disk teeth immersed in the material. This provision however increases the total dead time of the cutting operation. When the disk fully cuts the material on a thickness of 2 or 3 cm, lower yields are acceptable.

[0018] As regards the diamond blades the phenomenon is more incisive and its negative effects are more evident. While in a disk all segments come out from the material to be cut for the most of its rotation, in a gang-saw only the segments on the two extremities of the blades come out alternatively from the block purging the abraded material.

[0019] The worse situation is found in the centre of the block where the material abraded by each travel is dragged in the following cutting cycle and only long after reaches one or the other end of the block. This helps to explain why, using a gang-saw, it is possible to cut only materials having a hardness far from that of the diamond and it is impossible to cut granites and other hard materials because of the excessive counter-abrasive effect of the abraded material on diamond.

[0020] Figure 1 shows schematically in a lateral view a cutting tool or blade, realised according to the prior art, in contact with a stone block 3 to be cut and having, on the lower cutting edge, a plurality of diamond segments 2.

[0021] In Figure 2 the same blade is shown from the top, during cutting of stone block 3. The abraded material during the reciprocating movement of the blade accumulates in hatched areas 4 included between segments 2.

[0022] Because of the counter-abrasive effect on the diamond segments, at present it is not possible and economically convenient to cut granite and hard materials using diamond segment gang-saws.

[0023] In a horizontal gang-saw the abraded material that rises laterally, because of the reduced thickness of the blade relative to the segments, falls, because of the gravity, between the same segments and is dragged again onward and backward until it is able to find an exit at one of the extremities of the block.

[0024] Analogous problems arise in vertical gang-saws having one-way diamond blades in the active stroke zone in contact with the block to be cut, worsened by the fact, with respect to the disk, that the contact area between tool and material is longer and by the reduced speed of the tool.

[0025] Some attempts have been made in order to facilitate the drainage of the abraded material from the cutting area, modifying the shape and the surfaces of the diamond segments or the tool core, disk or blade.

[0026] For example the Patent Application WO 95/22446 discloses a disk with diamond segments hav-

ing a thickness oversized in the zone of contact and decreasing towards the disk core in a plurality of steps inclined with respect to the cutting direction.

[0027] In European Patent Application EP 0 287 847 the external surface of the diamond segments is zig-zag shaped or has similar grooves in order to facilitate the drainage of abraded material.

[0028] In Patent US 4,550,708 between the teeth of a disk are placed some openings having the same length of the segment in order to collect the abraded material.

[0029] The Patent US 4,490,039 provides for openings between the diamond teeth extending towards the centre of the disk while the teeth have grooves extending along their height forming channels for the drainage of material.

[0030] The known solutions however do not allow to improve considerably the drainage of abraded material in order to avoid the counter-abrasive effect on the tool, an essential provision for lengthening the tool life and accelerating the cutting process in particular when hard materials are cut.

[0031] A first object of the present invention is therefore to improve substantially the expulsion process of the abraded material, avoiding counter-abrasive effect and consequently lengthening the tool life.

[0032] These and other objects are reached by a shape and a disposition sequence of diamond segments having different profiles that allow a more efficient washing of the cutting groove guaranteeing the expulsion of abraded material with a continuous flow of the lubricating and washing water, as claimed in the enclosed claims.

[0033] The tool according to the invention can be advantageously used for cutting marble and calcareous stones but also for cutting granite and other very hard stones.

[0034] The aforesaid and other objects of the invention will become more evident from the description of a preferred embodiment with reference to the attached drawings in which:

Figure 1 is a lateral view of a diamond segments cutting tool according to prior art;

Figure 2 is a top view of the cutting tool of Figure 1;

Figure 3 is a lateral view of a diamond segments cutting tool according to the present invention;

Figure 4 is a front view of the tool of Figure 3;

Figure 5 is a perspective view of the tool of Figure 3;

Figure 6 is a lateral view of the tool of Figure 3 in which are highlighted the discharge flows of the abraded material;

Figure 7 is a bottom view of the tool of Figure 3 wherein are highlighted the discharge flows of the abraded material;

Figure 8 is a lateral view of a second embodiment of a diamond segments cutting tool according to the

present invention;

Figure 9 is a front view of the tool of Figure 8;

Figure 10 is a lateral view of the tool of Figure 8 wherein are highlighted the discharge flows of the abraded material;

Figure 11 is a bottom view of the tool of Figure 8 wherein are highlighted the discharge flows of the abraded material;

Figure 12 is a lateral view of a disk shaped cutting tool provided with diamond segments realised according to the present invention; and

Figure 13 is a perspective view of an alternative embodiment of a tool realised according to the present invention.

[0035] With reference to Figures 3 to 12 will now be described a cutting method, according to the invention, which allows to continuously cut stone blocks or similar materials using a diamond segments tool.

[0036] The method provides the steps of:

realise a first groove having a width L1 by means of a first segment 12 having height H1;

enlarge said first groove realising a second groove, having width L2 greater than L1, by means of a second segment 14 having height H2 less than H1;

enlarge said second groove realising a third groove, having width L3 greater than L2, by means of a third segment 16 having height H3 less than H2.

[0037] This method allows the tool to remove the material progressively, each segment working on a reduced section and therefore on previously weakened material. Moreover, since the three segments realise grooves of different sections, it is always guaranteed a continuous water flow, laterally and below the segments, which facilitates discharge of abraded material.

[0038] With reference to Figure 3 it is shown, in a schematic lateral view, a cutting tool 1 realised according to the present invention, in particular a diamond segments blade.

[0039] A metal core 10, which in this case is a linear metal band but could be as well a circular disk, has a lower edge 18 to which are applied, by means of weld joints 20, diamond segments 12, 14, 16 made of a mixture of abrasive material and a binder whose characteristics and proportions depend from the material to be cut.

[0040] According to the invention the diamond segments are arranged on the blade according to repeated sequences of different segments. Each sequence comprise three segments 12, 14, 16 having, according to a preferred cutting direction pointed out by the arrow 22, a height progressively decreasing and a cutting width progressively increasing.

[0041] A first segment 12 has indeed a height H1 greater than the height H2 of the second segment 14, which is in turn higher than the third segment having

height H3.

[0042] The first segment 12 however is narrower, cutting width L1, then the second segment 14, cutting width L2, which is in turn narrower than the last segment 16, having width L3.

[0043] The segments of every repeated sequence on the blade must therefore have the following characteristics: $H1 > H2 > H3$ e $L1 < L2 < L3$.

[0044] Each segment digs in the stone a groove having a profile different from that of adjacent segments, defining thus a continuous and always open path for the abraded material, carried by the water flow used for its drainage and for cooling the blade during cutting.

[0045] In Figure 4, wherein it is visible frontally the tool of Figure 3, are evident the different heights and widths of the three segments 12, 14, 16, present in each sequence.

[0046] Figure 5 shows, in a perspective view, the tool 1 previously shown in Figures 3 and 4. In particular it is visible a sequence of segments 12, 14 and 16, fixed to core 10, having height H progressively decreasing and width L progressively increasing.

[0047] The new shape and the group configuration is useful for diamond disks and for gangsaw diamond blades, wherein it finds a better application in a mono-directional operation of the gangsaw in which the tools are in contact with the material only during the active cycle.

[0048] The configuration however is valid also in a bidirectional gangsaw wherein remains the problem of a easier undermining of the single diamonds from the binder because of the reciprocating movement.

[0049] Similar sequences of segments having the same characteristics can be applied also to disk shaped cores, in this case however the external surface of each segment should follow the disk curvature with a radius increased by the height of the segment.

[0050] According to the invention, a sequence of cutting segments could contain a number of segments different from three, for example only two, or four, five or even more.

[0051] In Figures 6 and 7 are shown in detail, respectively in a lateral view and in a bottom view, the drainage flows forming during cutting that always guarantee a complete removal of the abraded material by means of water flow.

[0052] In each Figure are shown two sequences of three segments 12, 14 and 16 during cutting of a stone block 3.

[0053] The spaces 22 comprised between single segments are obviously hollow spaces for the passage of water and abraded material. Now will be analysed the possible drainage flows near each segment.

[0054] The first segment 12, whose lower portion 26 is immersed in the stone, has laterally two zones 24, horizontally hatched, for lateral drainage, in that it moves in a larger channel dug by the second 14 and third 16 segment.

[0055] The second segment 14 has a portion 26 immersed in the stone, one lower drainage zone 28, vertically hatched, corresponding to the channel dug by the first segment, and two lateral drainage zones 24, corresponding to the larger channel dug by the third segment 16. The third segment 16 is laterally immersed in the

[0056] stone, while under it is present a drainage flow 28 corresponding to the channels dug by segments 12 and 14 that precede it.

[0057] Moreover segments 14 and 16 can eventually provide for a central frontal drainage, as shown in detail in Figure 13, made of a longitudinal groove 60, 62, obtained in the lower part of each segment.

[0058] Thanks to all these passages and thanks to the hollow spaces 22 present between segments it is therefore guaranteed a continuous channel along all the cutting area, which greatly facilitates the drainage function performed by cooling water and that avoids completely the counter-abrasion effect on the segments, in that the abraded material can always and easily find a fast escape path.

[0059] The first segment 12, more projecting and thinner, can have a thickness which is lower than that of the metal core 10 of the blade while the last segment 16, the less projecting and thicker of the series, defines the lifetime of the tool.

[0060] The segments comprised in each sequence can advantageously have different lengths, in order to compensate the different heights and widths maintaining constant their volume. This way it is possible to compensate, balancing the wear of various segments, the amount of abrasive material present in each segment. Likewise, for similar requirements, the single segments can also have different mixture characteristics as regards abrasive materials and binding materials.

[0061] Normally indeed the cutting segments comprise, according to the use, particles of natural or artificial diamond, polycrystalline portions of tungsten carbide or other hard materials, together with various binder materials, for example copper alloys for marbles and soft stones or cobalt alloys for granite and hard stones. This particular arrangement on the blade core of diamond segments having different profiles has also the advantage of progressively fretting the material, each segment working on a reduced section and therefore on weakened material. This allows to obtain straight cuts and a better drop speed between the blade and the stone block.

[0062] Figures 8 and 9 show, laterally and frontally, a second embodiment of a cutting tool according to the present invention. Three cutting segments 32, 34 and 36, arranged in sequence according to the above described characteristics of decreasing height and increasing width, are joined together in a single cutting element 30. The cutting element 30 can therefore be considered a single segment divided in three different portions, a first portion 32 narrow and high, a middle

portion 34 and a last portion 36 lower and larger than the preceding ones.

[0063] This one segment 30, although having reduced drainage capabilities with respect to the above described embodiment, has the advantage of an easier assembling and/or alignment on the blade or disk core.

[0064] In order to facilitate the passage of the abraded material and the cooling water between adjacent portions 32, 34 and 34, 36, in correspondence with the discontinuities between the lateral surfaces, are present some vertical grooves 31 perpendicular to the cutting direction of the tool.

[0065] In Figures 10 and 11 are shown in detail, respectively in a lateral view and in a bottom view, the drainage flows that form during cutting with the tool shown in Figures 8 and 9.

[0066] In each Figure are shown three segments 30, separated by spaces 42, each segment being made of three different portions 32, 34 and 36, during cutting of a stone block 3.

[0067] The spaces 42 comprised between adjacent segments are obviously open spaces for the passage of water and abraded material. Now will be analysed the possible drainage flows near the single portions of each segment.

[0068] The first portion 32 has a lower portion 46 immersed in the stone and has laterally two zones 44, horizontally hatched in Figure, for lateral drainage near the larger channels dug by the second 14 and third 16 portions.

[0069] The second portion 34 has a part 46 immersed in the stone, one lower drainage zone 48, vertically hatched, corresponding to the channel dug by the first portion, and two lateral drainage zones 44, corresponding to the larger channel dug by the third portion 36.

[0070] The third portion 36 is on the contrary laterally immersed in the stone, while under it is present a drainage flow 48 corresponding to the channels dug by the portion preceding it.

[0071] The vertical grooves 31 facilitate the passage of the abraded material between adjacent portions of the same segment creating a continuity among various drainage flows.

[0072] In Figure 12 it is shown another embodiment of a cutting tool using diamond segments according to the invention. The segments are arranged, according to ordered sequences 50, on the circumference 11 of a disk shaped metal core 10.

[0073] According to the invention the diamond segments are arranged on the disk according to repeated sequences of different segments. Each sequence comprises three segments 52, 54 and 56 having, with respect to the preferred cutting direction pointed out in Figure by the arrow 13, progressively decreasing height and progressively increasing cutting width.

[0074] With regard to the diamond blades it is evident that better results as regards wear are obtained on

mono-directional gangsaws, in particular if the blade frame is moved away from the material to be cut in correspondence of end of stroke zones, wherein the speed is zero or close to zero, and during backstroke.

Claims

1. Tool (1) for cutting granite, marble, stone or similar materials, comprising a metal core (10) to which are applied a plurality of cutting segments (12, 14, 16) made of a mixture of abrasive material and binder material, characterised in that said plurality of segments (12, 14, 16) comprises repeated sequences of two or more different segments, said segments having, inside each sequence, progressively decreasing heights and progressively increasing cutting widths, with respect to a preferred cutting direction of the tool.
2. Tool according to claim 1, wherein each sequence comprises at least three segments (12, 14, 16) having different height and cutting width, applied to the core (10) spaced with each other.
3. Tool according to claim 1, wherein the segments contained into each sequence have different lengths, in order to maintain constant their volume and therefore the amount of abrasive material present in each segment.
4. Tool according to claim 1, wherein the segments comprised in each sequence have different mixture characteristics of abrasive material and binder material.
5. Tool according to claim 1, wherein at least one of the segments comprised in a sequence has a central frontal drainage (60; 62) made of a longitudinal groove.
6. Tool according to claim 1, wherein the segments contained into each sequence are part of a single cutting element (30) made of a single piece and applied to a metal core (10) of the tool.
7. Tool according to claim 6, wherein, in correspondence of discontinuity points among the lateral surfaces of two adjacent segments, are present grooves (31) perpendicular to a cutting direction of the tool.
8. Tool according to any of the preceding claims, wherein said metal core (10) is a metal disk and the external surfaces of the cutting segments follow the disk curvature with a radius increased by the height of the same segments.
9. Tool according to any of the claims 1 to 7, wherein

said metal core (10) is a metal blade.

10. Tool according to any of the preceding claims, wherein said cutting segments contain natural or artificial diamond particles or polycrystalline portions of tungsten carbide or other hard materials.
11. Segment set (12, 14, 16) containing abrasive material for a cutting tool, characterised in that it comprises at least two segments, arranged in sequence according to a cutting direction of the tool, each segment having, relative to the segment preceding it in the sequence, respectively lower height and greater cutting width.
12. Segment (30) containing abrasive material for a cutting tool, characterised in that it comprises at least two different portions (32, 34, 36), arranged in sequence according to a cutting direction of the tool, each portion having, relative to the portion preceding it in the sequence, respectively lower height and greater cutting width.
13. Segment according to claim 12, comprising, in correspondence of discontinuity points among the lateral surfaces of two adjacent portions, grooves (31) perpendicular to a cutting direction of the tool.
14. Method for continuous cutting along a cutting line blocks of stone or similar materials by means of a tool provided with segments containing abrasive material, characterised in that it comprises the steps:
 - realise along said cutting line a first groove having width L1 by means of a first segment (12) having height H1;
 - enlarge said first groove realising a second groove, having width L2 greater than L1, by means of a second segment (14) having height H2 less than H1.
15. Method according to claim 14, further comprising the step of enlarge said second groove realising a third groove, having width L3 greater than L2, by means of a third segment (16) having height H3 less than H2.

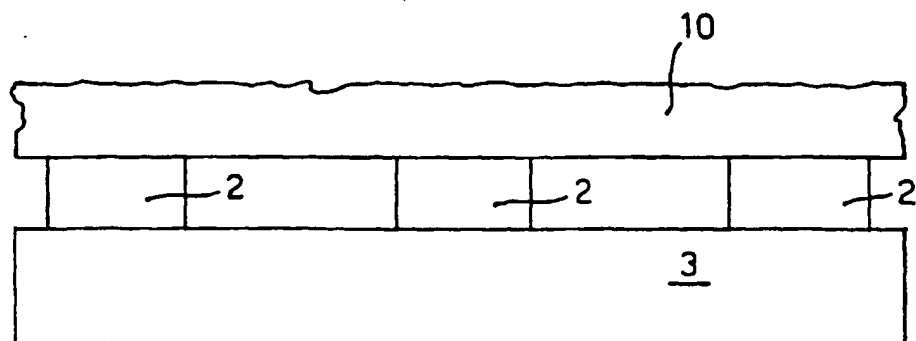


FIG. 1

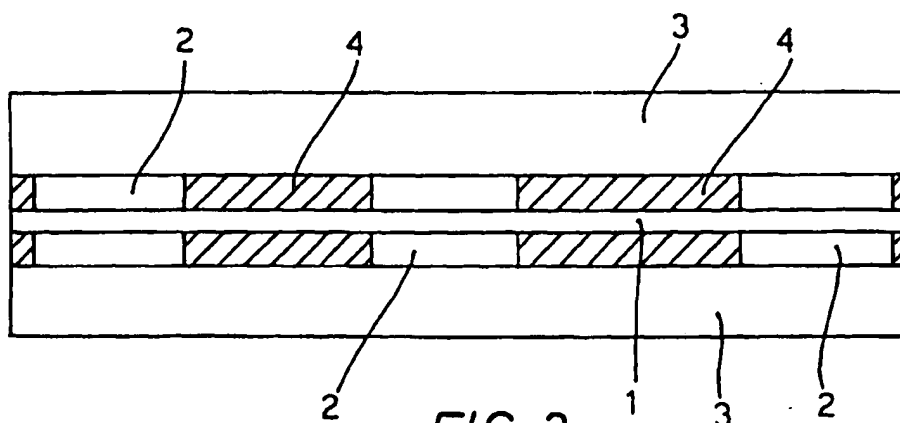


FIG. 2

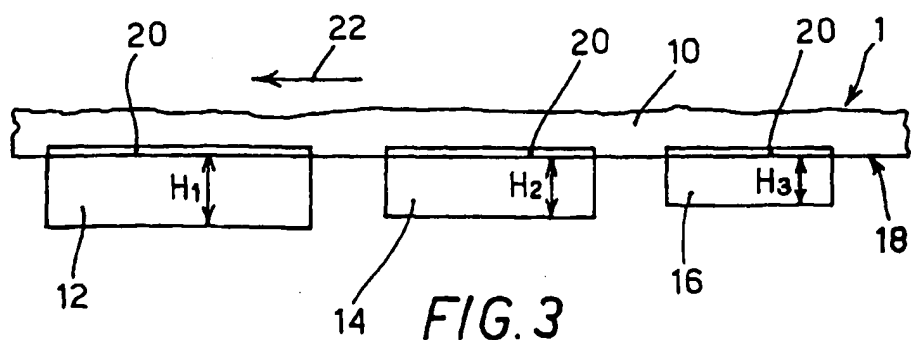
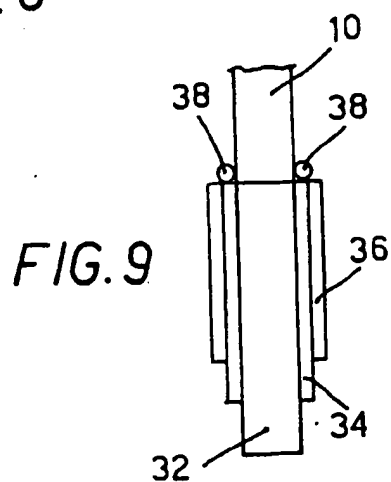
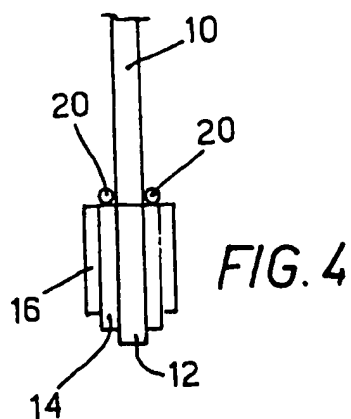
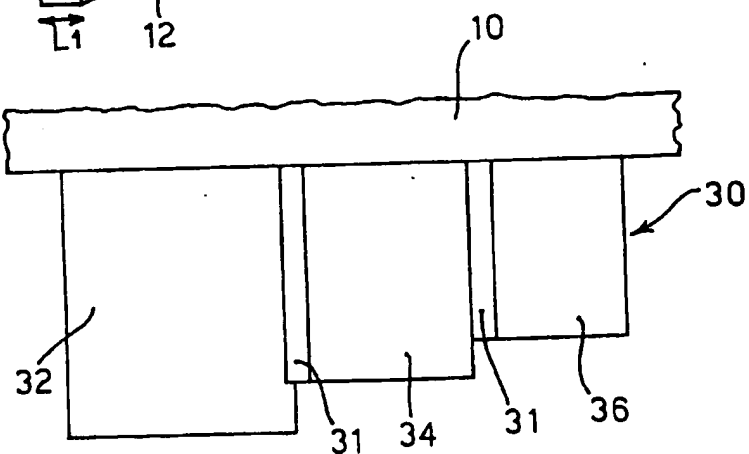
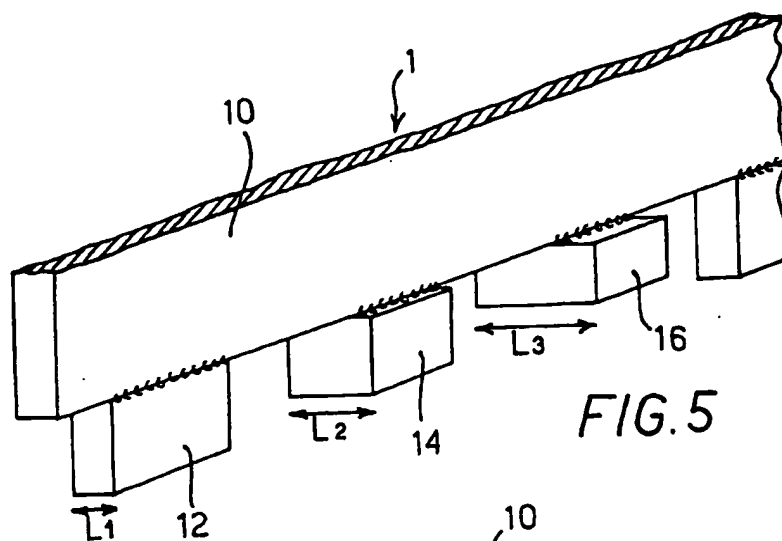
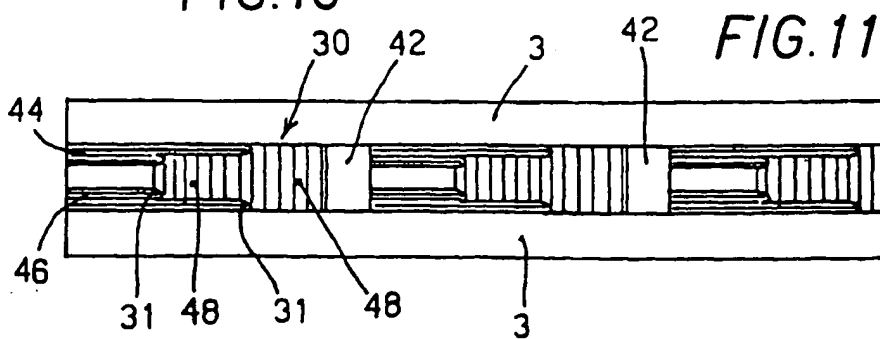
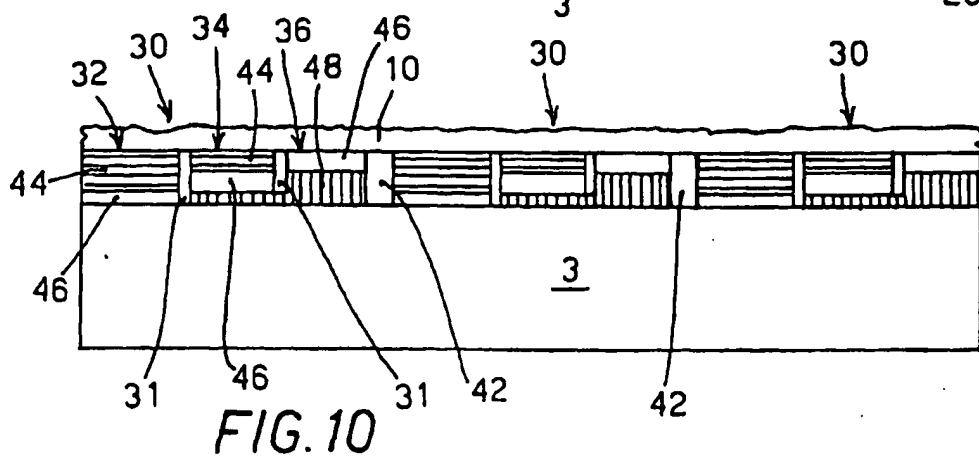
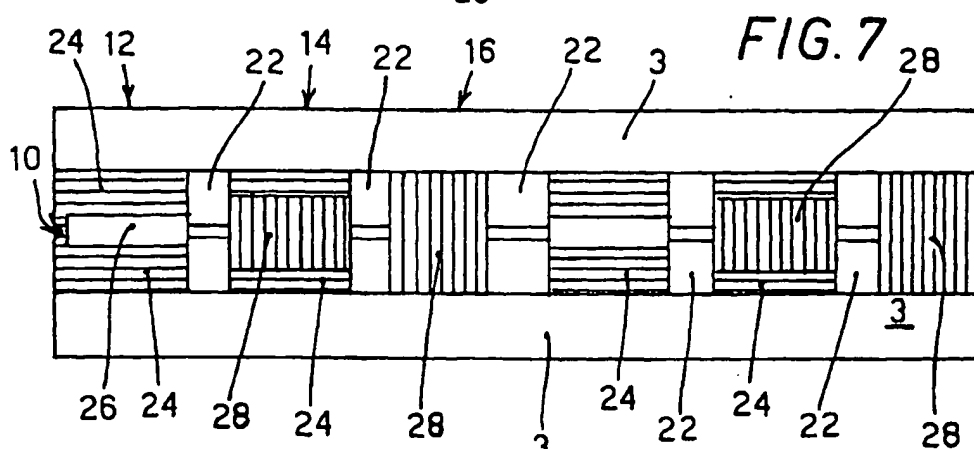
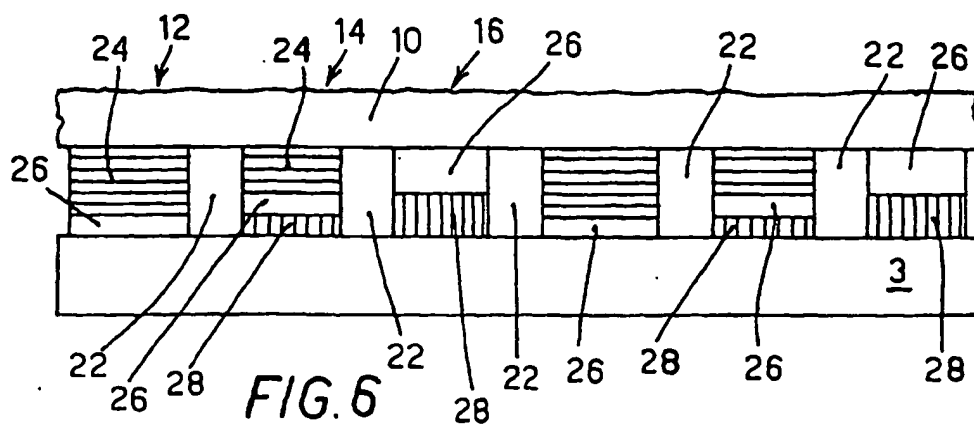


FIG. 3





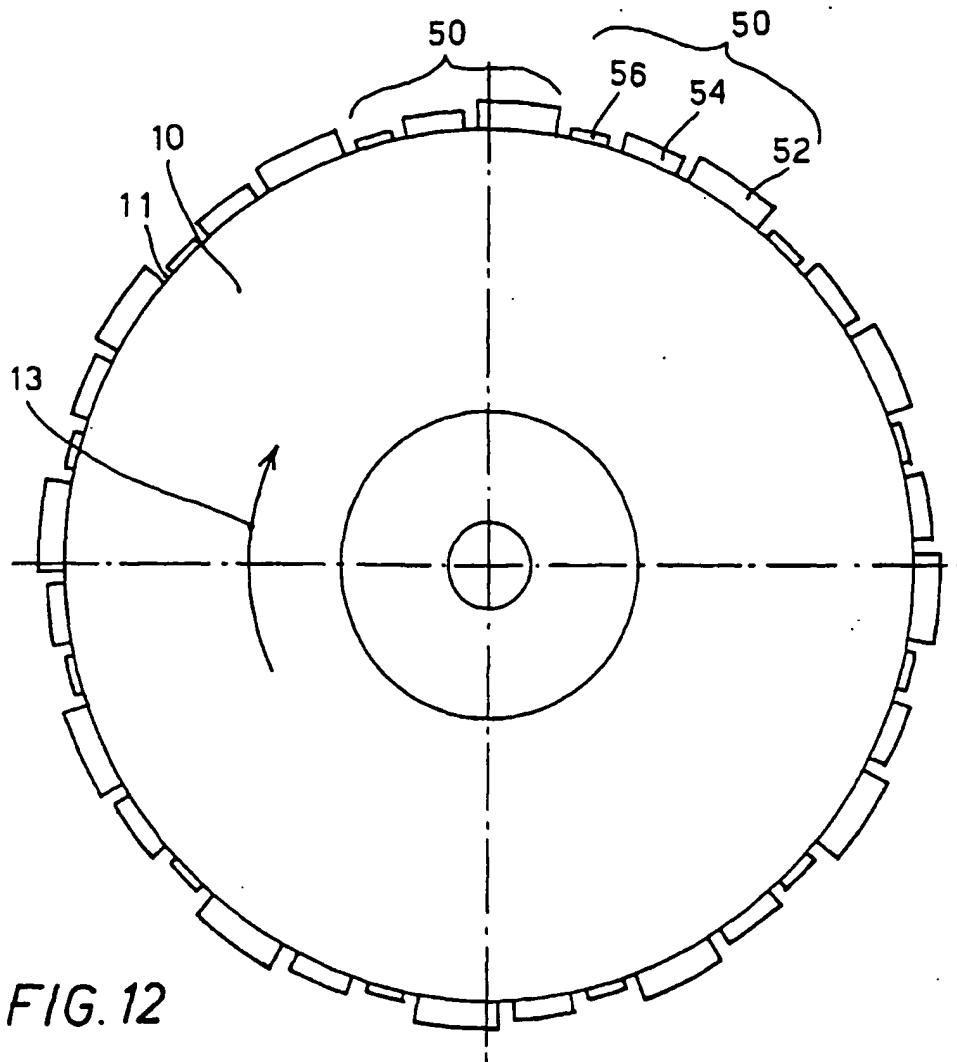


FIG. 12

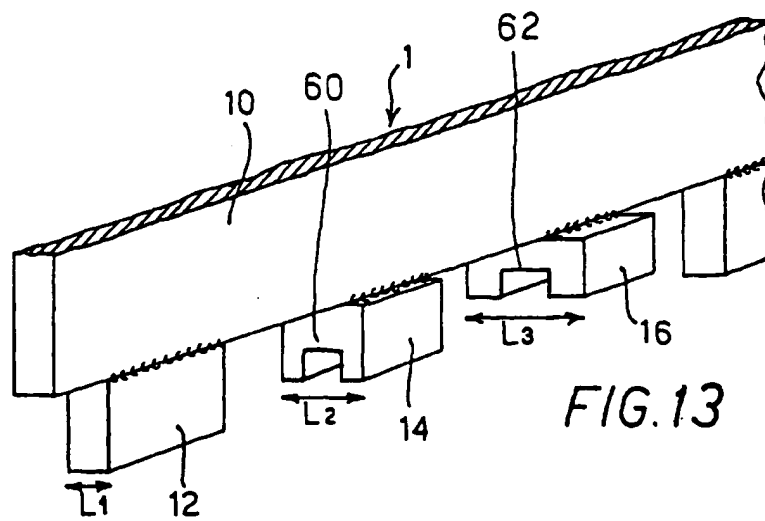


FIG. 13



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 99 83 0160

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Place of search THE HAGUE		Date of completion of the search 19 August 1999	Examiner Moet, H
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date O : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

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Application Number
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 19 August 1999	Examiner Moet, H
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P4/C31)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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